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The Influence of Viewing Angle on Elk Hiding Cover in Young Timber Stands

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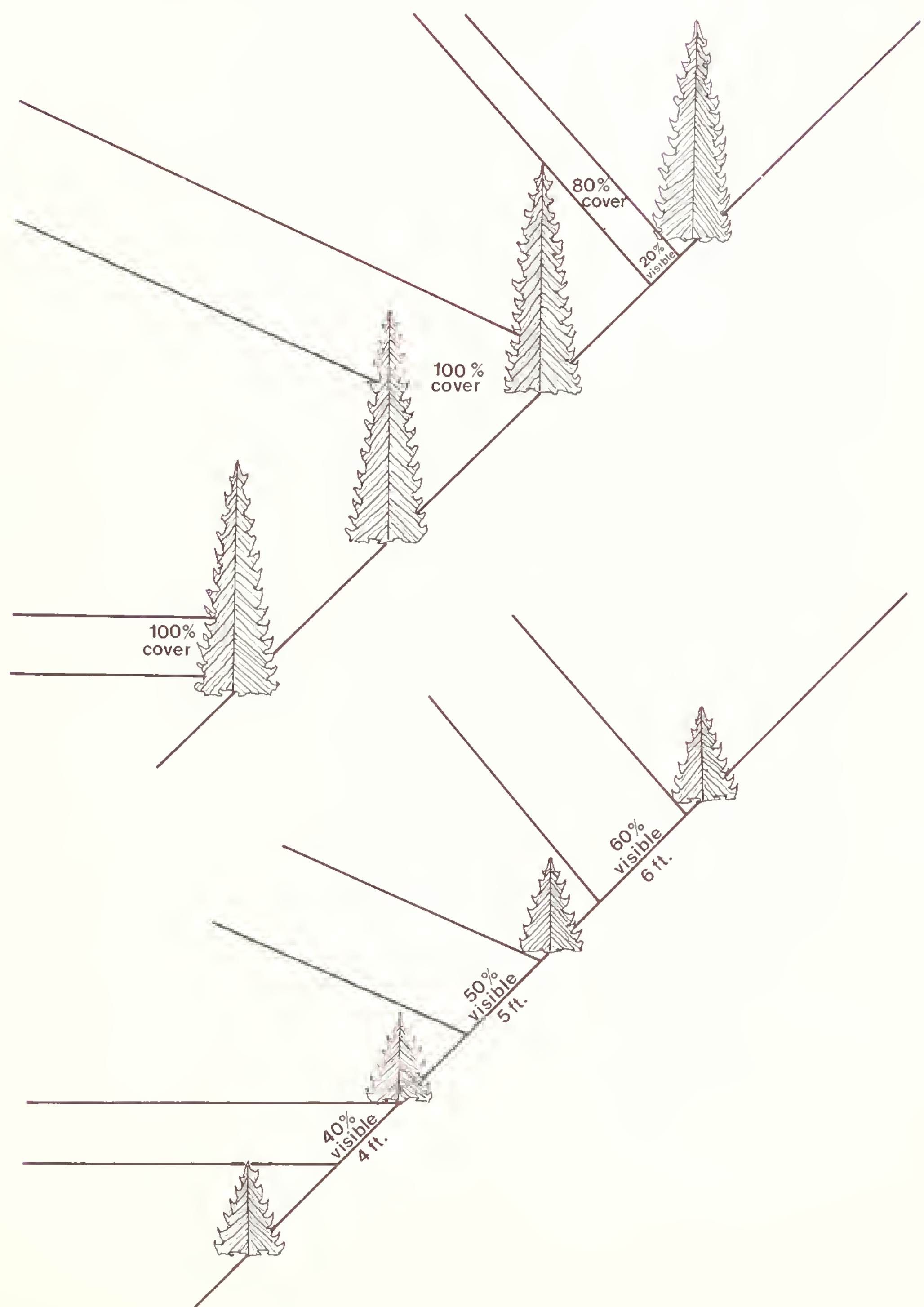

RESEARCH SUMMARY

Young timber stands, even when providing 100 percent visual concealment for elk when viewed on a horizontal plane, may provide 50 percent or less cover when viewed from an opposing slope at an elevated viewing angle. The higher the viewing angle, the greater the relative cover loss. In a simple linear model, viewing angle explained 52 percent of the variation in hiding cover values. Slightly more variation was accounted for when the data were stratified by tree height. On the average, for a 10-degree elevation in viewing angle, hiding cover decreased by 10 percent. The cover loss relationship was most pronounced in stands with the steepest topography, the shortest trees, and the lowest tree and shrub densities.

THE AUTHORS

JODIE E. CANFIELD has been associated with the Lolo National Forest in a temporary position testing Forest Plan assumptions about elk habitat and vegetative relationships. She attended Oregon State University and received B.S. and M.S. degrees in wildlife management from Montana State University. Her M.S. degree thesis, completed in 1984, reported the effects of a 500-kv transmission line on wintering elk populations.

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INTRODUCTION

Habitat effectiveness for elk is closely tied to the quality of security cover (Lyon and others 1985). Because forested lands in western Montana have high values for both timber and elk, it is desirable to schedule timber harvest so that adequate amounts of elk hiding cover are continually available.

Land managers have assumed that cutover stands begin to provide hiding cover when conifers are 6 to 8 ft in height. Well-stocked, regenerating stands of this height will provide hiding cover about 15 years after harvest. The National Forests in western Montana recognize the need for elk hiding cover in timber harvest areas with constraints or policies intended to prevent the removal of cover stands adjacent to clearcuts until the clearcut has trees of this height. Evaluations are based on data from timber and wildlife habitat inventories or aerial photos and do not normally consider hiding cover values from observation points outside the stand.

Steep dissected topography, common in the Northern Rockies, often allows an observer to stand on slopes opposing cutover areas and look down into young stands of conifers. Our initial observations suggested that hiding cover values are dramatically compromised by elevated viewing angles. Consequently, existing evaluation methods may overestimate elk hiding cover values.

This study was conducted on the Lolo and Deerlodge National Forests of Montana as a means of testing the hypothesis that elk hiding cover values in young timber stands decrease proportionately as viewing angle increases from the horizontal.

The specific objectives of this study were:

1. To determine the relative loss in hiding cover values associated with changing the angle from which a stand is viewed.
2. To develop a model for describing any such losses in hiding cover.
3. To provide guidelines for improving elk/timber management strategies in forested areas with dissected topography.

Fieldwork was started in June 1985 and completed the following September. Funding and logistical support were provided by the Lolo and Deerlodge National Forests and the Intermountain Research Station.

STUDY SITE AND METHODS

Study sites were selected on the Lolo and Deerlodge National Forests in areas with dissected topography. Within these areas, sample stands were selected with trees between 5 and 25 ft tall and with an opposing slope providing an unobstructed view into the sample stand. Information on stand age and treatment was available from Forest Service timber inventory records.

Within a representative portion of a stand, a 250-ft transect was laid out across the slope. Transects consisted of five tangential circular plots, each with radius of 25 ft. Slope, aspect, elevation, and habitat type (Pfister and others 1977) were recorded for each transect. Within each circular plot, basal area, tree density, shrub density, canopy cover, tree crown height, and tree species were recorded.

At each plot center, a cover board (Nudds 1977) was evaluated by an observer 50 ft away, at the next plot center. The observer estimated the proportion of each of four equally spaced panels covered by vegetation, assigning a 0 for no cover, and up to a 5 for complete cover.

The influence of viewing angle on hiding cover was quantified using a modification of a method developed by Mike Hillis on the Lolo National Forest. A "target" individual moved randomly along the transect while an observer on the opposite slope recorded the percentage of 20 observations, taken at 5-second intervals, that the target was not visible as a human torso. This was defined as the "Hillis hiding cover." Observation points were typically located in the valley and progressively uphill on the slope opposite the study stand. We recorded two to five replications per stand, with successive sampling points 10 or more degrees of slope apart. The slope within the stand, on line of sight to the observer, plus the angle from the observer to the target, was defined as the viewing angle (fig. 1).

In most situations, as the viewing angle increased, distance between the observer and the target also increased. There was no evidence in our data that distances less than 1,000 ft biased the observer's ability to distinguish the target as human torso.

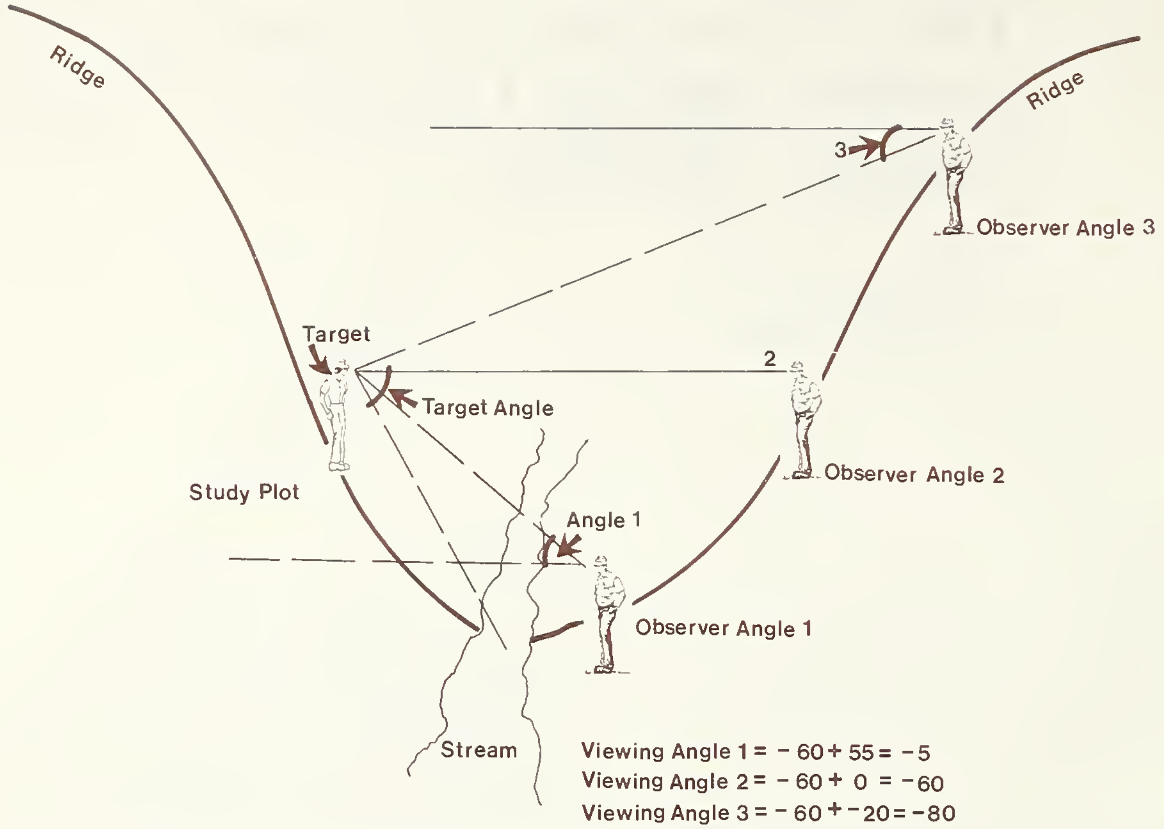

Figure 1—Hillis hiding cover estimation by observer to target in study plot. Hiding cover is the percentage of 20 observations that the target is not visible for a given viewing angle.

ANALYSIS

Raw data from 147 stands were transcribed and summarized to produce averages of measured stand parameters for each transect. Analysis was keyed to predicting the relative loss in hiding cover depending on the angle from which a stand is viewed.

Within each study stand, the regression of Hillis hiding cover values on viewing angles was calculated. The resulting Y-intercept was taken as the projected Hillis cover value of the stand with the viewing angle zero. Hillis cover values were then subtracted from the projected cover value (Y-intercept) to predict cover loss values expressed as units of percentage points.

The basic relationship, regression of cover loss on viewing angle, was assumed to be related to some or all of the vegetative factors measured. This assumption was tested by stratifying the data along a gradient of values for each vegetative factor and fitting a line or a curve to each level of stratification. In addition, discriminate analysis was used to identify those vegetative factors most useful in separating stands classified by the slope of their individual linear regressions.

RESULTS

The average number of Hillis hiding cover measurements in 144 stands was 3.67. Three stands with only one observation were excluded from the analyses. Table 1 lists the means, standard deviations, and ranges of several descriptive variables recorded for study stands.

Table 1—Means standard deviations (s.d.), and ranges for selected variables recorded for study stands (N = 144)

Variable	Mean	s.d.	Range
Basal area	14.2	17.3	0-54
Trees/acre	497	600	84-2,458
Shrubs/acre	167	298	0-2,649
Canopy cover percentage	16.9	21.3	0-69
Tree height (ft)	12.5	13.2	5-27
Slope percentage	34	16	3-63
Elevation (ft)	5,268	663	4,040-7,280
Age (years)	19	20	6-35

For each study stand, the Hillis hiding cover values (Y-axis) were plotted against their corresponding viewing angle (X-axis). The slope and Y-intercept values from the linear regressions ranged from 0 to 2.48 and 38 to 100, respectively. The average slope was 0.9617, and the average Y-intercept was 79.

Stands were placed into three categories based on rate of change in hiding cover relative to changes in viewing angle. Table 2 presents the means of vegetative measurements in each category.

Table 2 shows that, on the average, stands with the least change in hiding cover relative to change in viewing angle had the highest values for all vegetative factors except tree density.

Table 2—Mean values for some vegetative measurements for three groups of stands based on the slope of individual regressions

Slope category	Basal area	Trees/acre	Shrubs/acre	Canopy cover	Tree height
	Acres			*Percent*	*Feet*
0.00-0.74	16.9	522	250	24	13.9
0.75-1.19	12.8	416	150	16	12.9
1.20-2.48	12.6	544	122	10	10.4

Using basal area, tree density, shrub density, canopy cover, and tree height as independent variables, discriminate analysis correctly classified 55 percent of the study stands into the proper slope category. Canopy cover and tree height had the highest canonical coefficients. Because tree height is more easily measured than canopy cover, it was selected for use in further analyses.

An attempt was made to detect correlations between stand projected cover values (Y-intercept) and stand vegetative factors. No highly significant correlations were found. Hiding cover values within the stand, measured with a cover board, were only moderately correlated with the stand Y-intercepts.

Because each stand produced between two and five estimates of Hillis hiding cover, a total of 525 (x,y) pairs were included in the overall regression of cover loss on viewing angle.

The overall linear regression is graphed in figure 2 for viewing angles between 0 and 75 degrees. A curvilinear model fitted to the data improved the r value from the linear r, but not significantly. The standard error of the estimate was 13.88. Values for slope, Y-intercept, and the correlation coefficient, and their 95 percent confidence intervals are given in table 3.

We assumed that the variance in the overall regression was due in part to some vegetative factor. Only linear stratifications on tree height and canopy cover proved significantly different from a single overall equation.

The three equations based on groups of tree height are graphed in figure 3. Values for the regression parameters and the standard error of the regressions ($S_{y.x}$) are given in table 4. Curvilinear functions improved the correlation coefficients an average of 13 percent. This was not a significant improvement.

Table 3—Values and confidence intervals for the regression of cover loss on viewing angle (N = 525), Y = 3.76 + 0.713X

Factor	Estimated value	95% confidence interval
Slope (*b*)	0.7127	0.6539-0.7715
Y-intercept (*a*)	3.76	2.58-4.94
Correlation (*r*)	.72	0.68-0.76

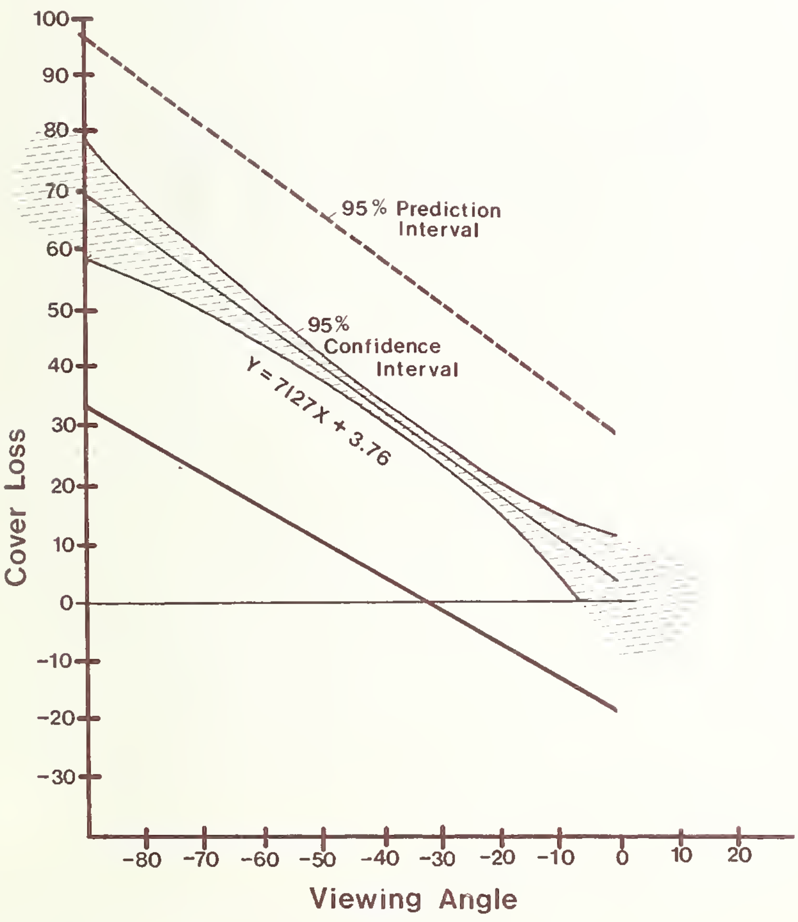

Figure 2—Comprehensive linear model (N = 525). Cover loss predicted from viewing angle.

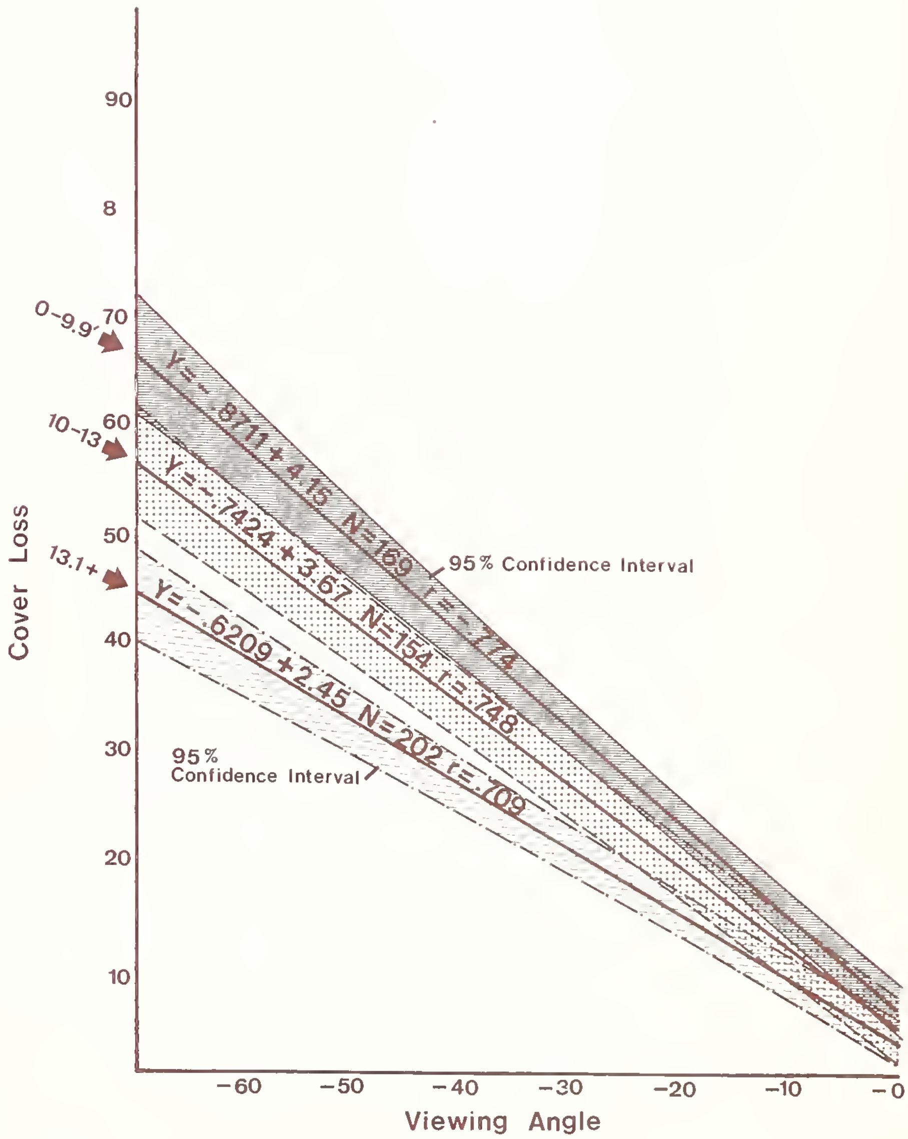

Figure 3—Linear models and 95 percent confidence intervals for three classes of tree height. Cover loss predicted from viewing angle.

Table 4—Standard error of the estimates, regression parameter values, and 95 percent confidence intervals for three linear models based on tree height

Height group	N	$S_{y.x}$	Slope	Mean Y	Mean X	r
5-9.9	169	13.7	0.8711 ± 0.118	24.74 ± 2.1	– 23.64	0.774 ± 0.06
10-13	154	14.3	.7424 ± .118	24.65 ± 2.3	– 28.26	.748 ± .08
13.1-21	202	12.2	.6209 ± .078	20.89 ± 1.7	– 29.70	.709 ± .06

Statistical tests showed the short tree and tall tree models to be significantly different. Although neither the slope nor the Y-intercept of the medium height model were significantly different from the short tree model, there was significantly less unexplained variance using two separate models over a single combined model. The regression line for medium height trees was parallel to the line for tall trees.

In figure 3, the regression lines diverge as the viewing angle increases. The mean values of Y predicted from each of the three linear equations were significantly different for viewing angles greater than 10 degrees.

All tree heights in the sample, from 5 to 21 ft (there was one stand with trees 27 ft tall), showed a hiding cover loss with increasing viewing angle, although the rate of hiding cover loss relative to viewing angle declined as tree height increased. The threshold of tree height after which the relationship does not exist is greater than 21 ft. From field observations, we estimate this height to be 25 to 30 ft.

We detected no significant correlation between tree height in a stand and the age or treatment of the stand, even when stands were grouped by habitat type. However, the majority of the stands were clearcuts between 15 and 25 years old.

DISCUSSION

The stands included in this study were quite diverse. They included samples from the relatively open, rolling hill lodgepole stands of the Deerlodge National Forest, to the steep, closed Douglas-fir and subalpine fir stands typical of the Lolo National Forest. Therefore, the results should be applicable to all situations in which timber is harvested in areas with some topographic relief.

Only a few documented methods exist for quantifying hiding cover for wildlife. For elk, cover that conceals 90 percent of an animal at a distance less than 200 ft is considered hiding cover (Thomas and others 1976). We used two methods for measuring hiding cover in this study—a cover board for within-stand evaluation and the modified Hillis method for evaluating cover from outside the stand. Cover board measurements were only moderately correlated with Hillis values at viewing angles near zero. Therefore, the Hillis method is relevant only in the sense that a measurement of 100 percent Hillis cover at one angle, and a reading of 85 percent at a higher angle, constitute a cover loss of 15 percentage points.

We had assumed that cover loss was a function of the vegetative factors we chose to measure. None of the analyses confirmed this assumption. The distribution of vegetation and its vertical structure may also be important but would be difficult to measure or quantify. Shrub height may also be important. Furthermore, different combinations of vegetative features can be equally effective at providing cover. For example, a stand with a few big trees and abundant shrubs may provide the same cover as a stand with dense short trees and no shrubs. Overall, as would be expected, the cover loss/angle relationship was least pronounced in stands with thick boles, tall trees, and dense shrubs. Although many other factors are involved, tree height appears to be the variable most responsible for buffering cover loss from steep viewing angles. That is, as tree height increases, there is a trigonometric layering effect that obstructs view into the stand even at elevated viewing angles (see cover).

Although slightly more variation was explained using curvilinear functions, the linear models were selected for simplicity. For angles between 0 and 50 degrees, the regression was steep and linear. At angles greater than 50 degrees, cover loss leveled. There seemed to be a threshold angle for each stand beyond which no further changes in cover could be detected. Only in very open stands did hiding cover decline to zero.

Changes in viewing angle (one variable) explained 52 percent of the variation in cover loss in the combined linear model, 60 percent in the short tree model, 56 percent for trees 10 to 13 ft tall, and 50 percent for trees 14 to 21 ft tall.

Given clearcuts with young trees, the cover loss/angle relationship will be pronounced in areas of steep topography and in narrow valleys. In these situations, observation points are typically outside of a stand. Conversely, on relatively level ground, and in wide canyons where distance to the opposing slope is greater than 0.25 mile, it is unlikely that this relationship will be important.

Although it was not addressed in this study, stands dominated by western larch (*Larix occidentalis*) may be particularly vulnerable to hiding cover loss at elevated viewing angles in the fall after needle drop. This is significant in that it is concurrent with heavy recreational use of forest roads by hunters.

Clearcuts may provide foraging areas for elk in heavily timbered areas. However, the use of seral stages for foraging is often tempered by the quality of security cover in the adjacent forest (Irwin and Peek 1983; Lyon and Jensen 1980). Elk tend to underutilize habitat near forest roads that are open to vehicular traffic. This avoidance is especially pronounced in areas of poor security cover and during the big-game hunting season (Irwin and Peek 1983; Lyon 1979). Therefore, the security of elk habitat in areas where timber is harvested depends on the spacial arrangement of cutting units and the management of roads.

MANAGEMENT RECOMMENDATIONS

The cover loss phenomenon can be minimized and hiding cover for wildlife can be continually available if resource planners implement the following recommendations in areas with steep, timbered topography:

1. Stagger timber harvest units so that opposing slopes and adjacent units are never cut concurrently. This will ensure that a clearcut cannot be viewed from an opposing slope and that security cover is available on the edges of a cut.
2. In relatively steep topographic situations where a young timber stand can be viewed from an opposing slope, delay reentry until trees are 25 to 30 ft tall.
3. Avoid, when possible, building roads across an uncut slope that opposes a cutover unit. These roads provide a viewing angle into cut stands. The higher on a slope a road is built, the greater the potential hiding cover loss in the opposing stand.
4. Implement road closures in areas of steep dissected topography where timber harvest has been extensive. Close existing roads where they provide access across an uncut slope that opposes a cut slope. Road closures are especially critical during the fall hunting season.

The impact of these recommendations on timber harvest yield and economics is considered low. Initial sampling on the Lolo Forest has indicated that viewing angle relationships play a significant role on only about 20 percent of the lands allocated for timber harvest. Consequently, these recommendations can be viewed as a valuable management tool for achieving desired elk summer range with minimal impacts on the timber resource.

To ensure the continued enjoyment of the many resources on our National Forests, the interactions of those resources and their uses must be considered. Where elk habitat exists on forested public land, it is essential that security cover be continually available. This study reveals that young timber stands are not effective at providing elk hiding cover where topography is dissected and the observation point is outside and above the stand. The hiding cover loss associated with elevated viewing angles can be minimized with careful planning and cooperation between timber and wildlife managers.

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Young timber stands that provide hiding cover for elk when viewed on a horizontal plane provide far less security when viewed from an opposing slope at an elevated viewing angle. On the average, for a 10-degree elevation in viewing angle, hiding cover decreases by 10 percent.

KEYWORDS: hiding cover, viewing angle, elk

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